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Coronary Artery Disease and Noncardiac Surgery: Considerations in Anesthesia Nursing

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CORONARY ARTERY DISEASE AND NONCARDIAC SURGERY: CONSIDERATIONS IN ANESTHESIA NURSING

by

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Abstract

The issue addressed in this paper was the concept of patients with coronary artery disease going for non-cardiac surgery, including anesthesia considerations during surgery. The exploration of anesthesia considerations in patients with a history of coronary artery disease is important, because the nurse anesthetist needs to: a) be aware of the incidence of coronary artery disease, b) be knowledgeable regarding the pathophysiology involved in coronary artery disease to assist in prompt diagnosis and treatment of ischemia, c) plan and carry out an appropriate anesthetic plan during surgery, d) be knowledgeable in the treatment of a patient who suffers a myocardial infarction during the intraoperative phase and, e) be knowledgeable of techniques during the postoperative phase to minimize adverse cardiac events. This project covers material related to the role of the nurse anesthetist in treating patients with coronary artery disease and concludes with recommendations for nursing research, policy, education and practice.

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Coronary Artery Disease and Noncardiac Surgery: Considerations in Anesthesia Nursing

Cardiovascular disease is the leading cause of death in the United States, Canada, Europe, and Japan. (World Health Organization, 1990). Due to the rise in coronary artery disease, it is likely that a large amount of patients presenting for surgery will have a history of coronary artery disease. As many as 27 million men and women have some type of surgery each year in the United States and it is estimated that 1 million experience perioperative cardiac complications. Many of those patients who experience perioperative complications have coronary artery disease. Over the next several decades the effects of aging on the population will exacerbate the problem of cardiac complications after surgery. It is estimated that more than 37 million patients will undergo surgery in the future and 40% will either have, or be at risk for, coronary artery disease (CAD) (Mangano, 1990).

Women on average have a six year longer life span than men. The longer life span means a substantial amount of surgical patients will be women. Although the prevalence of coronary artery disease is greater in men at all ages, the occurrence of coronary artery disease after the age of 65 years is higher in women (Liu, Wiener & Kornish, 1998). Coronary artery disease is the leading cause of death in women over 50 years of age, accounting for 250,000 annual deaths in the United States alone (Ullrich, Yeater & Dalal, 1992). Cardiac morbidity and mortality for women can be expected to increase due to the progressive aging of the population and the predominance of women in the elderly populations (Liu, 1998). Nurse anesthetists play an important part in evaluating the risk factors of patients to help reduce cardiac complications during noncardiac surgeries.

The aging population will continue to live longer than past generations due to current technology available. As the aging population grows the increase in CAD also grows. Therefore, it is not surprising that cardiac complications occur when these patients are subjected to stress during the 3rd to 4th postoperative day. Current estimates of serious perioperative cardiac morbidity vary between one and ten percent, depending on the subset of patients and the type of surgical procedure. About four percent of patients suffer serious perioperative cardiac mortality following noncardiac surgery (Mangano, 1990).

The prevalence of coronary artery disease leads to a frequent occurrence of myocardial ischemia during noncardiac surgery. The nurse anesthetist plays an important part in implementing the appropriate pharmacological and anesthetic interventions, which will improve perioperative outcomes for the patient.

Studies of noncardiac surgical patients have demonstrated that the period of highest risk for development of ischemia and adverse cardiac outcomes is the postoperative period. Earlier studies found that the cause was due to increased coagulation state, persistent tachycardia, and the stresses of pain and increased ambulation (Ramsay, 1996). The nurse anesthetist must continue to monitor the patient through out the postoperative course to minimize the risk of cardiac complications, which are more likely to occur during the hospital stay for that particular surgery.

Problem Statement

The issue examined in this paper is anesthesia considerations in patients with coronary artery disease going for noncardiac surgery. The preoperative phase included the assessment phase and appropriate diagnostic tests were discussed. The different phases of anesthesia discussed preinduction, induction, and maintenance in relation to CAD. The postoperative period covered common arrhythmias, pulmonary congestion and pain management options following surgery.

Purpose Statement

The examination of anesthesia considerations in patients with CAD undergoing noncardiac surgery is important because the nurse anesthetist must:

1. Be aware of the incidence of CAD in society.
2. Be knowledgeable regarding the pathophysiology and risk factors involved in CAD to assist in recognition of patients who may be at a higher risk for a myocardial infarction.
3. Be knowledgeable in prompt recognition of myocardial ischemia and infarction to initiate prompt treatment.
4. Be knowledgeable in current recommendations regarding anesthesia techniques to minimize the risk of adverse cardiac outcomes.

Research Questions

Five research questions were addressed:

1. What is the current recommendation for preoperative testing for patients with CAD?
2. What anesthesia considerations, relating to the preinduction, induction, maintenance and postoperative phase is of primary importance in regard to CAD?
3. What are the treatment options during the intraoperative phase for myocardial ischemia that could lead to an infarction?
4. What common arrhythmias occur postoperatively and treatment options available?

5. Why is postoperative pain control important in the CAD population and what are current recommendations for pain management?

Definitions

The following definitions were utilized in explaining the five research questions.

1. Coronary artery disease is commonly due to an obstruction of the coronary arteries by atheromatus plaques (Braunwald, 1997).
2. The two most important risk factors for atherosclerosis is male gender and increasing age. Three additional risk factors include hypercholesterolemia, systemic hypertension and cigarette smoking. Other proposed risk factors include diabetes mellitus, obesity, a sedentary lifestyle, and a family history of ischemic heart disease.
3. Myocardial ischemia occurs when there is occlusion of one or more coronary arteries or their branches that results in decreased perfusion of areas in the myocardium served by those vessels. Perfusion becomes insufficient to meet the metabolic demands of the heart and results in increased lactic acid build up (Hansen, 1998).
4. Myocardial infarction is a result of prolonged ischemia and death of myocardial cells (Hansen, 1998).
5. Anesthesia considerations examine the evaluation phase looking at the preoperative evaluation and appropriate diagnostic testing, induction, and maintenance. The postoperative phase covers common arrhythmias, pulmonary congestion and the importance of pain management in preventing adverse cardiac outcomes.

Physiological Framework

Physiological related changes with age with age

The common myocardial changes in older adults consist of an increase in the size of myocytes and also in the rate of degenerative changes, such as lipid deposition, and a decrease in myocardial phosphorylation. As a result of advancing age the heart is less able to adapt to hemodynamic challenges. There is a progressive age associated loss of myocytes, even though the myocyte volume per nucleus increases in both ventricles. The overall size of the heart does not increase but the left ventricular wall may increase slightly. The valves and conduction of the heart are not affected by age (Wei, 1992).

In terms of vascular changes the proximal portion of the artery tends to change first and eventually involves the entire vessel. The left coronary artery in the heart usually changes before the right one, with lesions initially appearing during youth or mid-adulthood. The right and posterior descending arteries do not commonly change until after the fifth decade of life. Within the intima of the artery the endothelial cells contribute to less laminar blood flow and the number of sites for lipid deposition may increase with age. The subendothelial layer thickens, and its connective tissue, calcium and lipid content increases with age. In the media layer the smooth muscle layer thickens. These age related changes tend to increase the stiffness of the vessel walls and most likely result in the compensatory loss of myocytes and hypertrophy of the heart (Wei, 1992).

Cardiac output during rest and exercise tends to decrease with age. Heart rate, loading conditions (preload and afterload), intrinsic muscle performance, and neurohumoral regulation are the determinants of cardiac output that may be influenced by age. The maximal heart rate during physical exercise decreases progressively, as does heart rate in response to most physiologic stimuli. Early diastolic ventricular loading declines and by 70 years of age it is reduced to approximately half of the value at the age of 30. Therefore, preload becomes considerably dependent on atrial contraction. The ascending aorta becomes stiffer and contributes to a rise in afterload. With increasing age, the length of time required for the myocardium to relax is increased. This overall process requires more oxygen and energy than does contraction and ultimately is more vulnerable to hypoxia and ischemia (Wei, 1992).

CAD and Atherosclerosis

CAD is most commonly due to an obstruction of the coronary arteries by atheromatous plaque also commonly referred to as atherosclerosis. The principal cause of death in Western civilization is due to atherosclerosis. The disease is progressive and generally begins in middle to late adulthood. In the past, atherosclerosis was considered to be a degenerative process due to the accumulation of lipid and necrotic disease in the advanced lesions. Today atherosclerosis is considered a multifactorial process, which results in extensive accumulation of smooth muscle cells within the intima of the affected artery (Braunwald, 1997).

Atherosclerosis is a disease of the arteries that through deposition of fatty lesions on the intimal layer, leads to thickening and hardening of medium to large size arteries. The fatty deposits are called atheromatous plaques, which start as crystals of cholesterol sticking to the intima and underlying smooth muscle. As the crystals develop, they form a larger matrix that stimulates surrounding fibrous and smooth muscle tissue growth to create additional layers onto which larger plaque can grow. Over time as the plaque matures, they develop into total obstructive lesions and contribute to the formation of fibroblasts that eventfully deposit dense connective tissue, resulting in sclerosis. As a result, the arteries become thickened, lose elasticity, and can become completely hardened (Nagelhout & Zaglaniczny, 2001).

In the later stages of plaque formation, loss of arterial distensibility and tissue degeneration can lead to ulceration of the arterial wall or formation of an embolus. As a result of blood flowing across plaque that projects into the blood stream, thrombi may develop and eventually form an embolus that, when released, can obstruct blood flow completely and lead to distal tissue ischemia (Naglehout & Zaglaniczny, 2001).

Myocardial Ischemia and Infarction

Occlusion of one or more coronary arteries or their branches will result in decreased perfusion of the myocardium served by those vessels. When perfusion becomes insufficient to meet the metabolic demands of the heart then ischemia occurs that leads to accumulation of lactic acid. Pain, electrical conduction impairment and muscle contraction follow that result in toxic injury and impaired membrane transport. Prolonged ischemia will result in myocardial infarction leading to death of myocardial cells.

An inflammatory response is triggered by ischemic damage to the myocardial cells. The ischemic damage leads to necrosis of myocardial cells, which then release intracellular enzymes into the blood. Myocardial infarction results in a lethal ischemic injury to a particular part of the myocardium. Surrounding the infracted area is a region of "stunned" myocardial cells that are damaged but still viable. These cells become dysfunctional for a time but have the ability to recover if perfusion is restored and drug therapy is instituted to stimulate cardiac contraction. Myocardial damage can become complete and irreversible within three to four hours or less, unless the infarcted area is perfused by collateral circulation or the occluded artery is opened by surgical intervention (Hansen, 1998).

Literature Review

Incidence and Prevalence

Heart disease remains the most frequent single cause of death among persons over 65 years of age despite the decline in rates of mortality. It also accounts for the growing proportion of hospitalizations and health care costs in the elderly (Wei, 1992). Studies have consistently shown that older patients are at a higher risk for cardiac complications, and in most studies age is shown to be an independent factor, even after controlling for the severity of cardiac disease and other comorbid conditions. Although chronological age is not a perfect predictor of frailty, older patients clearly have less physiologic reserve and increasing rates of cardiac disease. In the elderly the severity of cardiac disease may be masked by the patients diminished exercise levels and other health problems (Goldman, 1995).

Polanczyk et al. (2001) conducted a retrospective study that looked at the impact of age on perioperative complications and length of stay in patients undergoing noncardiac surgery. Their sample consisted of 4315 patients older than 50 years undergoing noncardiac surgery. Major or fatal perioperative complications occurred in 4.3% of patients younger than 59 years of age, in 5.7% of patients 70-79 years of age, and in 12.5% of patients 80 years and older. In addition, age was significantly associated with a higher risk for developing cardiogenic pulmonary edema, myocardial infarction, ventricular arrhythmias, bacterial pneumonia, and respiratory failure requiring intubation and increased hospital mortality. The data were consistent with other findings from previous investigations assessing the impact on age on perioperative complications, particularly cardiac complications.

A study conducted by Mangano et al. (1990) looked at the association of perioperative myocardial ischemia with cardiac morbididty and mortality in men undergoing noncardiac surgery. The goal of the study was to determine the predictors of adverse cardiac outcomes in order to guide future efforts on prevention and treatment as the ability to predict patients who are at a higher risk for cardiac outcomes may decrease the number of adverse outcomes. The researchers prospectively studied 474 men of which 243 had CAD and 231 were at a high risk for developing CAD undergoing noncardiac surgery.

The researchers gathered historical, clinical, laboratory, and physiologic data during the hospitalization period and up to 6 to 24 months following surgery. The results showed that eighty-three patients (18%) had postoperative ischemic cardiac events in the hospital. Postoperative myocardial ischemia occurred in 41% of the monitored patients and was associated with a 2.8 increase in the odds of all adverse cardiac outcomes and a 9.2 fold increase in the odds of an ischemic event. The findings emphasized the importance of the postoperative period and validated the work of previous investigators who had demonstrated the importance of the patient's chronic disease status before surgery and as well as the physiologic changes during the operation. According to Ashton et al. (1993) the risk of perioperative death from cardiac causes is less than 1% for patients who do not have coronary artery disease, as indicated by the history or by electrocardiographic evidence of myocardial infarction, typical angina, or angiographically documented coronary artery disease. In contrast, the risk of perioperative infarction or cardiac death is about twice as high in studies of patients with known or suspected coronary or atherosclerotic vascular disease. Patients undergoing peripheral vascular or aortic surgery have an increased risk of death due to cardiac causes such as, myocardial infarction, unstable angina, or ischemic pulmonary edema. The risk of death can be as high as twenty nine percent.

The overall risk of surgery has dramatically decreased during the past 20 to 30 years, and although perioperative cardiac morbidity remains the leading cause of postoperative and long-term mortality, these events are infrequent for all classes of procedures. The decrease in adverse perioperative events results from both improvement in surgical technique and advances in perioperative monitoring and management. The risk of surgery depends on the type of surgery and correlates somewhat with the presence or absence of significant surgical factors. The surgical factors consist of urgency, duration, location, perioperative fluid shifts, and aortic procedures (Wirthlin & Cambria, 1998).

Eagle et al. (1996) categorized different operative procedures including endoscopic, ophthalmologic, breast, and other superficial procedures as being low risk (reported cardiac risk generally less that 1%). Intermediate procedures consisted of carotid, head and neck, intrathoracic, intraperitoneal and orthopedic as being intermediate risk (reported cardiac risk often less than 5 %).

The operation associated with the highest risk is aortic aneurysm repair because these patients have an increased risk of noncardiac postoperative complications due to underlying coronary artery disease (Goldman, 1995). Operations that are associated with more difficult postoperative recuperation include major abdominal and thoracic operations, and tend to carry a higher risk than surgeries not associated with postoperative hypoxemia, major fluid shifts, and bleeding. Patients having major vascular surgery are more apt to have atherosclerotic coronary disease, which contributes to their increased risk because of the prevalence of the underlying problem.

Ashton et al. (1993) and many other studies have shown that vascular surgery carries an increased risk for cardiac complications. Some of the risk factors that contribute to vascular disease are diabetes mellitus, smoking and hyperlipidemia, which are also risk factors for CAD. Patients with these conditions may not present with the usual symptoms of CAD because they may be obscured by exercise limitations due to advanced age or intermittent claudication. Major arterial operations often are time consuming and are associated with major fluctuations in fluid volumes, cardiac filling pressures, systemic blood pressure, heart rate and thrombogenicity.

Patients who undergo emergency operations are at a higher risk than similar patients undergoing elective surgery, because they are more likely to suffer noncardiac complications. According to Mangano (1990) cardiac complications are two to five times more likely to occur with emergency surgical procedures than with elective operations. This finding is not shocking because the need for immediate surgical intervention may make it impossible to evaluate and treat such patients optimally.

A study conducted by Hertzer (1982) consisted of 1000 patients being considered for peripheral vascular reconstruction who underwent preoperative coronary angiography. The results indicated that only 14% of those studied had normal coronary arteries. Among the patients suspected of having CAD, 78% had severe disease. Out of the patients who had no clinical evidence of heart disease, 49% had moderate and 37% had severe CAD. The presence of CAD in these patients is clinically relevant. Among patients undergoing abdominal aortic aneurysm resection and aortoiliac reconstruction, early deaths due to cardiac causes occurred in 45 and 67%, respectively. Long-term follow-up revealed that cardiac disease was responsible for 38 to 55% of late deaths in both groups.

Anesthesia Considerations

Preoperative Evaluation

The American Society of Anesthesiologists (ASA) has developed a physical status classification system that helps determine the risk for surgery. The classification ideally represents a reflection of the patient's preoperative status and is not an estimate of anesthetic risk. Although a patient in poor physical health is know to be at a greater risk for a negative outcome, this does not account for other factors that influence perioperative morbidity and mortality. These factors include the duration and involvement of the surgical procedure, the degree of perioperative monitoring, and unfortunate circumstances, such as human error or equipment failure (Nagelhout & Zaglaniczny, 2001).

In a prospective study of 6301 surgical patients conducted in a university hospital, the association between ASA physical status classification and perioperative risk factors, and postoperative outcomes was evaluated. The method utilized was a univariate analysis and calculation of the odds ratio for the risk of developing postoperative complications was conducted. Univariate analysis showed a significant correlation based on the results between ASA class and perioperative variables, postoperative complications and mortality rate. The authors concluded that ASA physical status classification was a predictor of postoperative outcome (Wolters, Wolf, Stutzer & Schroeder, 1996). Thus the use of the ASA classification system can help identify patients at risk for intraoperative and postoperative complications, as well determining the appropriate anesthetic plan.

The greatest concern for anesthesia providers when caring for noncardiac surgery patients is the occurrence of cardiovascular complications in the form of ischemic events. Through careful monitoring and the use of prophylactic medications, the total risk can be minimized even though the ischemic events continue to be a major cause of morbidity and mortality (Leppo & Dahlberg, 1998). In the past, many of these high- risk patients were not considered for surgery. However, with the current advances in surgery and anesthetic techniques, high- risk patients are being sent for surgery more often. This presents an even greater need for preoperative risk assessment in order to minimize adverse events in these high-risk patients (Ferreira, 2000).

Preoperative assessment requires a team approach involving the cardiologist, anesthesia provider and surgeon (Ferreira, 2000). Clinicians can successfully use a cardiac risk stratification system to separate patients into various risk categories so that their management can be tailored to the patients particular needs. Ultimately, low risk patients may be spared further diagnostic testing, and postoperative management may be changed for patients indicated as high risk. The goal of risk stratification is to reduce overall mortality and morbidity of patients. The benefit of reducing perioperative complications and avoiding unnecessary testing can result in substantial cost savings (Palda & Detsky, 1997).

Cardiac risk assessment is a crucial aspect of the perioperative evaluation process, especially now with the concern for cost containment and many patients having their workup done as outpatients a few days before surgery. It is pertinent to consider the patient's clinical history, functional capacity, and type of surgery to decide if further noninvasive testing is necessary (Liu, 1998).

The history of identification of risk started in 1977 when Goldman, Caldera and Nuisbaum. (1977) Identified factors that increased the risk of cardiac complications during noncardiac surgery. A scoring system was devised based on nine factors. By 1986, the nine risk factors were expanded, further defined, and tested, yielding data that indicate that aortic stenosis, class IV angina, and recent myocardial infarction are the most significant risk factor in predicting a perioperative adverse cardiac event (Palda & Detsky, 1997). Further studies have lead to a modified scoring system that predicts patients at risk for adverse cardiac events during noncardiac surgery.

In (1999) Dr. Lee et al, published a new revised index that identified six variables as predictors of postoperative complications. The six variables consisted of a history of ischemic heart disease, congestive heart failure, high-risk surgery, cerebrovascular disease, treatment with insulin and preoperative serum creatinine levels greater than 177mmol/L. For most patients a thorough history, physical examination, and electrocardiogram are sufficient to assess perioperative cardiac risks factors. Further workup is needed for patients who are unable to exercise or cannot provide adequate history. High-risk patients should undergo further diagnostic testing only when the results will alter the management strategies and lead to improved outcome. Based on the previous studies, the most current guidelines have been published by The American College of Cardiology (ACC) and The American Heart Association (AHA) in 2002 (Eagle et al., 2002).

Preoperative risk stratification is extremely important in the elderly patient because often times the short and intermediate term prognosis is limited. It doesn't make much sense to subject an aged patient with severely reduced organ function to a major operation, knowing that the postoperative morbidity and mortality is high. Effective preoperative risk stratification may modify preoperative therapy, surgical approach, choice of anesthetic technique and agents, monitoring and postoperative care (Priebe, 2000).

As the potential for perioperative events increase with advancing age, preoperative assessment of organ function is particularly important in the elderly (Priebe, 2000). A careful history is crucial to the identification of cardiac and/or comorbid diseases that would place the patient in a high surgical risk category. The history should identify cardiac conditions such as prior angina, recent or past myocardial infarction, heart failure, and symptomatic arrthymias. It is also important to determine if the patient has a pace maker or implantable cardiac defibrillator or a history of orthostatic intolerance. It is important to record modifiable risk factors for coronary heart disease and other associated diseases such as peripheral vascular disease, cerebrovascular disease, diabetes mellitus, renal impairment, and chronic pulmonary disease. Accurate recording of current medications and dosages is essential to assist the anesthetist in the anesthesia plan. A history of alcohol and illicit drug use should be documented because of its effect on anesthetic drugs (Eagle et al., 2002).

In patients who have symptomatic coronary disease, the preoperative evaluation may lead to the recognition of a change in the frequency or pattern of anginal symptoms. Symptoms of cardiovascular disease should be carefully evaluated, especially symptoms of chest pain if present, because the presence of unstable angina has been associated with a high perioperative risk of myocardial infarction. The preoperative evaluation can impact both the patients short and long term health by instituting treatment of unstable angina (Fleisher, 2001).

The patient with a history of stable angina should be evaluated to determine the degree of exercise tolerance. The patient who gets angina only after strenuous activity and does not demonstrate signs of left ventricular dysfunction would not be a candidate for changes in anesthetic management. In contrast, a patient with dyspnea on mild exertion would be at high risk for developing perioperative ventricular dysfunction, myocardial ischemia, and possibly a myocardial infarction. These patients with dyspnea on mild exertion have an extremely high probability of having extensive CAD and additional monitoring should be evaluated depending on the surgical procedure and institutional policies (Fleisher, 2001).

Traditionally, risk assessment for noncardiac surgery was based upon the time interval between the myocardial infarction and surgery. Multiple studies have demonstrated an increased incidence of reinfarction if the myocardial infarction was within six months of the surgery (Fleisher, 2001). Rao, Jacobs and El-Etra (1983) reported 6% re-infarction rates among 48 patients who had surgery within three months of an MI, and 2% among those having surgery three to six months after an MI. Shah, Kleinamn, Sami, Patel and Rao (1990) reported re-infarction rates according to the type of surgery and found that even major operations were associated with reinfarction rates compared to those reported by Rao et al.

The importance of the intervening time between infarct and surgery may no longer be valid in the current era of thrombolytics, angioplasty and risk stratification after an acute MI. Many patients with a history of a myocardial infarction may continue to have myocardium at risk for subsequent ischemia and infarction, while other patients may have coronary stenosis either totally occluded or widely patent. The use of percutaneous transluminal coronary angioplasty is associated with a reduced incidence of death or reinfarction within 6 months. Therefore, patients should be evaluated from the perspective of their risk for ongoing ischemia. (Fleisher, 2001). The American Heart Association/American College of Cardiology Task Force has advocated the use of a myocardial infarction less than thirty days prior to surgery as the group with the highest risk, while after thirty days risk stratification is based upon the presentation of disease and exercise tolerance (Eagle et al., 2002).

The patient's history should include a thorough assessment of the patient's functional capacity to perform a spectrum of common daily tasks that have been shown to correlate well with maximum oxygen uptake by treadmill testing (Hlatky et al., 1989). In a study conducted by Reilly et al. (1999) the investigators looked at self-reported exercise tolerance and the risk of serious periopertaive complications. The results indicated that patients who reported poor exercise tolerance had more perioperative complications. Specifically, they had more myocardial ishemia, cardiovascular and neurologic events. The likelihood of a serious complication occurring was inversely related to the number of blocks that could be walked or flights of stairs that could be climbed. The data confirmed that both the severity of a patient's medical problems and the intensity of the procedure to be performed are important factors in determining perioperative risk.

Excellent exercise tolerance in patients with stable angina suggests that the myocardium can be stressed without becoming dysfunctional. If a patient can walk a mile without becoming short of breath, then the probability of extensive CAD is small. Alternatively, if a patient becomes dyspenic that is associated with chest pain during minimal exertion, the probability of extensive CAD is high (Fleisher, 2001). Surgery is a physically stressful event and patients with poor exercise tolerance will not tolerate it well (Reilly et al., 1999).

A thorough cardiovascular exam should include an assessment of vital signs (including measurement of blood pressure in both arms), carotid pulse for bruits, jugular venous pressure and pulsations, auscultation of the lungs, precordial palpation, abdominal palpation, and examination of the extremities for edema and vascular integrity (Eagle et al., 2002). Cardiac auscultation can provide useful clues to underlying cardiac disease. When present, a third heart sound at the apical area suggests a failing left ventricle, but its absence is not a reliable indicator of good ventricular function (Butman, Ewy, Stranden, Kern & Hahn, 1993).

When a murmur is present the clinician must decide whether or not it represents significant valvular disease. Detection of significant aortic stenosis is of particular importance because the lesion poses a higher risk for noncardiac surgery (Goldman, 1977). Significant mitral stenosis or regurgitation increases the risk of heart failure. Aortic regurgitation and mitral regurgitation may be minimal, but they predispose the patient to infective endocarditis should bacteremia occur after surgery. In these conditions the patient should be given endocarditis prophylaxis (Dajani et al., 1990).

The patient's general appearance can provide invaluable evidence regarding the patient's overall health status. Cyanosis, pallor, dyspnea during conversation or with minimal activity, cheyene stokes respirations, poor nutritional status, obesity, skeletal deformities, tremor, and anxiety are a few clues that can be recognized by a skilled professional (Eagle et al., 2002).

The anesthesia provider must evaluate the cardiovascular system within the framework of the patient's overall health. Associated conditions often heighten the risk of anesthesia and may complicate cardiac management. The presence of either obstructive or restrictive pulmonary disease places the patients at increased risk of developing postoperative respiratory complications. Hypoxemia, acidosis, and increased work of breathing can all lead to further deterioration of an already compromised cardiopulmonary system (Eagle et al., 2002).

A variety of metabolic diseases may accompany cardiac disease. The most common is diabetes mellitus and its presence may heighten the suspicion of CAD. Myocardial ischemia and CAD are more likely to be silent in patients with diabetes (Aronow & Ahn, 1999). Older patients with diabetes are more likely to develop heart failure postoperatively than those without diabetes even after adjustment for treatment with angiotension converting enzyme inhibitors. Axotemia is commonly associated with cardiac disease and with an increased risk of cardiovascular events. A significant number of patients with renal disease also have a history of diabetes mellitus. Fluid management can be a challenge in patients with renal disease to ensure adequate amount of fluid is given without placing them in cardiac failure. Preoperative serum creatinine between 1.4 and 2.0 has been identified as a risk factor for postoperative renal dysfunction and increases long-term morbidity and mortality compared with patients without renal disease (Samuels et al., 1996). Anemia imposes a stress on the cardiovascular system that may exacerbate myocardial ischemia and aggravate heart failure (Nelson, Fleishner & Rosenbaum, 1993).

Patients receiving long-term therapy for coronary artery disease, heart failure, or hypertension should receive medications throughout the periopertive period, including the day of surgery. It is especially important to maintain beta-blocker therapy, not only to minimize the probability of withdrawal effects, which may exacerbate ischemia or hypertension, but also because the immediate postoperative period is one of adrenergic over activity (Blaustein, 1995).

Several randomized trials have examined the impact of medical therapy consisted of beta-blockers begun prior to the scheduled surgery date. The most common utilized preoperative medications are beta-blockers to reduce the incidence of cardiac events. The first randomized, placebo-controlled study involved the perioperative use of atenolol in 200 high-risk patients who were scheduled to undergo noncardiac surgery. Overall the mortality after discharge from the hospital was significantly lower among the atenolol treated patients than among those who were given placebo over six months following discharge. Event free survival through out the two-year study period was 68% in the placebo group and 83% in the atenolol group (Mangano, Layug, Wallace & Tateo, 1996).

Poldermans and colleagues studied the perioperative use of bisprolol in elective major vascular surgery. The medication was started seven days preoperatively and dose adjustment was utilized to achieve a resting heart rate of no more than 60 beats per minute and continued for 30 days postoperatively. Bisporolol was associated with a reduction of approximately 91% in the perioperative risk of myocardial infarction or death from cardiac causes in this high-risk population (1999).

Boersma et al. (2001) looked at the predictors of cardiac events after major vascular surgery and the role of dobutamine echocardiography, and beta-blocker therapy. The researchers utilized a retrospective and non-randomized study of 1351 vascular patients. They reported cardiac complication rates were greatly reduced in most patient categories (98% of patients) by beta-blocker treatment. Only 2% of patients with three and more risk factors that included current angina, prior myocardial infarction, congestive heart failure, prior cerebrovascular accident and extensive dobutamine stress echocardiography induced ischemia did not profit from beta-blockade.

The safest conclusion to be drawn from current studies is that beta-blocker treatment should begin before surgery, even up to a month before the procedure, with titration of the dose-taking place as an outpatient procedure up to the time of anesthesia. Therapy should be continued at a minimum through hospitalization, and longer if adequate medical follow-up can be arranged postoperatively. Close follow-up was particularly important in the care of patients who are not receiving beta-blockers long term before surgery to ensure that the drug dose can be tapered if long-term use is not indicated. Follow-up is also imperative for patients receiving beta-blockers for medical reasons so that continuity in their medication is maintained (Auerbach & Goldman, 2002).

A recent retrospective study conducted by Schmidt, Lindeenauer, Fitzgerald and Benjamin (2002) reviewed administrative and medical records of 158 patients undergoing major noncardiac surgery. A total of 67 patients seemed to be ideal candidates for treatment with perioperative beta-blockers. Of the 67 patients, 25 received a beta-blocker at some time perioperatively. During the course of a year, they estimated that between 560 and 801 patients who did not receive beta-blockers might have benefited from their use. Full use of beta-blockers among eligible patients at that particular institute could result in 62 to 89 fewer deaths each year at an overall cost of $33,661 to $40,210. There seems to be a large opportunity to improve quality of care of patients undergoing major noncardiac surgery by increasing the use of beta-blockers in the perioperative period.

The effect of alpha2 adrenergic agonists has also been studied in the perioperative period. Several small, randomized studies comparing clonidine with placebo failed to demonstrate that clonidine reduced the rates of myocardial infarction and death from cardiac causes. For example, mivazerol, and intravenous alpha2 adrenergic agonist administered by continuous infusion, was compared with placebo in a cohort study of 2801 patients known to have coronary artery disease or risk factors for CAD. Patients in the study under went major vascular or orthopedic procedures. Results indicated that mivazerol was found to have no overall effect on the rates of cardiac complications (Oliver, Goldman, Julian & Holme, 1999).

Diagnostic Testing

The following section will discuss the recommendations from the American College of Cardiology and The American Heart Association for perioperative cardiovascular evaluation for noncardiac surgery. In most ambulatory patients the choice of test would be an exercise ECG. This test can provide an estimate of functional capacity and detect myocardial ischemia through changes in the ECG and hemodynamic response. In particular patients with important abnormalities on there resting ECG (left bundle branch block, left ventricular hypertrophy with strain pattern and a digitalis effect) other techniques such as exercise echocardiography or exercise myocardial perfusion imaging should be considered.

In patients who don't have the ability to perform adequate exercise, a nonexercise stress test should be utilized. The most common tests used currently are the dipyridamole myocardial perfusion imaging and the dobutamine echocardiography. Patients who have significant bronchospam, critical carotid disease or a condition that prevents them from being withdrawn from theophylline preparations should not undergo intravenous dipyridamole. Dobutamine should not be used as a stressor in patients with serious arrhythmias or severe hypertension or hypotension due to the adverse effects of the drug.

In patients for whom echocardiographic image quality is poor a myocardial perfusion study is more appropriate. If there are any additional questions about the patient's valvular dysfunction an echocardiographic stress test is the best option. In many situations a stress perfusion or stress echocardiography is appropriate (Eagle et al., 2002). A meta-analysis study looked at dobutamine stress echocardiography, ambulatory electrocardiography, radio nuclide ventriculography, and dipyridamole thallium scanning in predicting adverse cardiac outcomes after vascular surgery. All tests had a similar predictive value and overlapping confidence intervals. The local laboratory expertise in determining advanced coronary artery disease is more important than any particular type of test (Mantha et al., 1994).

Currently the use of ambulatory electrocardiography as a preoperative test should be restricted to identifying patients for whom additional surveillance or medical intervention might be beneficial. The current studies do not support the use of ambulatory electrocardiography as the only diagnostic test to refer patients for coronary angiogram. For those particular patients who are a high risk for adverse cardiac events, it may be appropriate to proceed with coronary angiography rather than perform a noninvasive test (Scanlon et al., 1999).

Anesthetic Technique

The anesthetic management of an elderly person will be determined primarily by the patient's state of heath, the anticipated surgical procedure and the skill and experience of the anesthetist. The elderly patient is not simply just an older younger individual. It is essential that adjustments be made to account for the aging of the body.

Multiple studies have examined the influence of anesthetic drugs and techniques on cardiac morbidity. The results of most studies have shown that there is not one anesthetic technique that is better for patients with a history of CAD. All anesthetics, techniques and drugs are associated with known effects that should be considered in the perioperative plan. For example, opiod based anesthetics have become popular because of the cardiovascular stability with their use. The adverse effect of the use of opiods is postoperative ventilation associated with high doses.

The overall goal of anesthetic choice is to maintain a balance between myocardial oxygen delivery and myocardial oxygen requirements in hopes of preventing a myocardial infarction. Persistent tachycardia, systolic hypertension, arterial hypoxemia and diastolic hypotension all affect the delicate balance between oxygen delivery versus demand (Eagle et al., 2002).

Regional versus general anesthesia has not shown any difference in adverse outcomes in previous studies. Bode et al. (1996) conducted a prospective, randomized controlled clinical trial involving 423 patients. They were randomly assigned to receive general, epidural, or spinal anesthesia for femoral to distal artery bypass surgery. The recorded cardiac outcomes were MI, angina, and congestive heart failure. There was no significant difference in cardiovascular morbidity and mortality between the two groups.

Christopherson et al. (1993) performed a randomized, controlled clinical trial involving 100 patients scheduled for elective peripheral vascular surgery. They were randomized to receive either epidural anesthesia followed by epidural analgesia or general anesthesia followed by intravenous patient controlled analgesia. Like Bode et al. (1996) they found no significant differences in a 6-month mortality, cardiac-related mortality, non-fatal MI, or unstable angina. Further studies conducted in patients undergoing carotid endarterecotomy, hip fracture surgery and gastrointestinal surgery did not reveal any difference in adverse cardiac outcomes between regional versus general anesthesia.

Induction

Pharmaceutical medications utilized in the management of patients with CAD should be continued throughout the preoperative period. Abrupt withdrawal from cardiac medications can result in undesirable changes in heart rate and blood pressure. High-risk patients will benefit from optimal preoperative anti-ischemia and anti-hypertensive therapy as well as pharmacological means to decrease anxiety. The ability to control the patient's anxiety will help decrease the sympathetic response to intubation. Patients are more likely to arrive in the operating room in a relaxed state if the anesthesia provider has explained the sequence in detail. (Stoelting & Diedorf, 2002).

Blood pressure, heart rate, and the ECG should be repeatedly assessed through the induction phase (Morgan & Mikhail, 1996).

Benzodiazepines are utilized for sedation, antianxiety effects, amnesia, anticonvulsant effects and mostly for induction of anesthesia. The most common benzodiazepine utilized in practice is midazolam. It is a water-soluble drug and works by increasing the binding of GABA (inhibitory neurotransmitter) leading to good anxiolytic and sedation properties. The drug has no effect on analgesia and produces anesthesia (Nagelhout & Zaglaniczny, 2001).

Thiopenthal is the most commonly used barbiturate in anesthesia. The drug works by binding to the GABA receptor, which produces hypnotic activity. Barbiturates produce few excitatory symptoms, with a rapid onset and a short duration, and also are associated with little pain on injection and few side effects. Etomidate is a non-barbiturate intravenous induction agent whose central nervous system effects result in hypnosis. Etomidate is famous for its cardiovascular stability and a wider margin of safety that appeared to challenge the long-standing role of thiopental as the induction agent of choice in intravenous anesthesia. The side effects consist of pain on injection and myoclonia, which has limited the use of the drug (Nagelhout & Zaglaniczny, 2001). Etomidate is an excellent choice for a patient with significant CAD because of the cardiovascular stability of the drug.

Propofol is utilized for the induction of anesthesia by producing suppression of brain stem function through interactions with the GABA receptor. The cardiovascular effects of propofol have been evaluated following its use both for induction and for

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Propofol is utilized for the induction of anesthesia by producing suppression of brain stem function through interactions with the GABA receptor. The cardiovascular effects of propofol have been evaluated following its use both for induction and for maintenance of anesthesia. The most prominent effect of propofol is a decrease in arterial blood pressure during induction of anesthesia. An induction dose of 2 to 2.5 mg/kg produces a 25% to 40% reduction in systolic blood pressure, and this is independent of the presence of cardiovascular disease. The decreased blood pressure is associated with a decrease in cardiac output, stroke volume index and systemic vascular resistance. Left ventricular stroke work index is also decreased by 30%. Heart rate does not significantly change with use of profolol (Patel, 2002). Caution has to be used with patients with a history of CAD to ensure they will be able to tolerate the drop in blood pressure. The dose needs to be adjusted in the elderly and the hypovolemic patient.

Ketamine is a phencyclidine derivative and has a pharmacological profile unique amongst anesthetic agents. It is unique in its cardiovascular effects in that it stimulates the cardiovascular system and is usually associated with an increase in blood pressure, heart rate and cardiac output. These responses are associated with increased myocardial work and oxygen consumption. The use of ketamine is contraindicated in patients with CAD and angina.

Ketamine is unique in that it produces significant analgesia and does not depress the respiratory system. The side effect of ketamine is that it produces some worrisome adverse psychological effects such as vivid dreaming, and misinterpretation of auditory and visual stimuli (Patel, 2002).

Opiods have been shown to produce greater cardiovascular stability when compared with inhalation agents. A common opiod is fentanyl, which lacks cardiovascular depression. Opiods produce less depression in cardiac output and a slight decrease in systemic vascular resistance. Opiods can provide the noncardiac patient with a history of CAD a stable heart rate and blood pressure. They blunt the sympathetic stimulation and maintain perfusion without the depressant effects on the heart. Critically ill patients with significant myocardial dysfunction require lower doses of and opiod for analgesia. Fentanyl rarely produces histamine release (Nagelhout & Zaglaniczny, 2001).

Neuromuscular blockers are utilized during intubation to facilitate placement of the endotracheal tube. They are commonly utilized in different surgeries to help facilitate muscle relaxation for the surgeon through out the case. The choice of muscle relaxant for patients with a history of coronary artery disease should focus on the impact these drugs have on the balance between myocardial oxygen requirements and oxygen delivery. Muscle relaxants that have minimal to no effects on heart rate, and systemic blood pressure are attractive choices for CAD patients (Stoelting & Diedorf, 2002).

Succinylcholine is a rapid acting depolarizing muscle relaxant that prolongs depolarization at the muscle end plate by resembling acetylcholine. The drug has a short duration of action of less than ten minutes. Succinylcholine is metabolized by plasma cholinesterase and can become prolonged in patients with deficient levels of plasma cholinesterase. The disadvantage of succinylcholine is its antagonistic action by which skeletal muscle is depolarized and then stimulates cardiac cholinergic receptors (Nagelhout & Zaglaniczny, 2001). Due to its structural similarity to acetylcholine it is expected to have some parasympathetic activity. The parasympathetic effects are infrequent and can be attenuated with atropine. Serum potassium increases after a dose of succinylcholine and caution has to be used in patients with an elevated potassium level

(Barish, Cullen & Stoelting, 2001). Succinylcholine is mostly utilized for emergency intubations and in patients with a history of esophageal reflux where time is important.

Rocuronium Bromide is a common nondepolarizing muscle relaxant that binds to the acetylcholine receptor to produce its effects. The nice thing about rocuronium is that it doesn't undergo any metabolism. The drug is eliminated primarily by the liver and slightly by the kidneys. Its duration of action is not significantly affected by renal disease but can be prolonged in liver failure. The onset of action is similar to succinylcholine making it suitable for modified rapid sequence intubations. Rocuronium is commonly used with patients with CAD because of its stable cardiovascular profile and no histamine release (Morgan & Mikhail, 1996).

Cisatracurium is another common nondepolaring muscle relaxant that is utilized in patients with a history of renal or liver failure. The advantage of cisatracurium is that it is not metabolized through any organ system. It does not release histamine and has a stable cardiovascular profile like rocuronium. The use of cisatracurium is common in the elderly population with CAD because most of those patients have a history of some organ dysfunction (Barish et al., 2001).

Inhalation Agents

Inhalation agents are the most common drugs utilized to maintain general anesthesia. The overall effect of volatile anesthetics is to produce unconsciousness and amnesia, which are essential components of general anesthesia. When combined with intravenous agents such as opiods and benzodiazepines a balanced technique is achieved that results in further sedation, hypnosis and analgesia. The ease of administration and the ability to predictably monitor their effects by end tidal concentrations has made inhalation agents a popular form of anesthesia. The cost of the agents is relatively inexpensive compared to the overall cost of anesthesia care for the patient. The dose is administered according to the minimum alveolar concentration (MAC). The MAC of an inhalation agent is the alveolar concentration at one atmosphere that prevents movement in response to a surgical stimulus in 50% of patients (Barish et al., 2001).

Tachycardia and hypertension increase myocardial oxygen demand, which contributes to development of myocardial ischemia associated with an increased risk of adverse cardiac events during the perioperative period (Agnew, Pennefather & Russel, 2002). In patients with coronary artery disease, hemodynamic control is one of the mainstays for prevention and treatment of myocardial ischemia. The goals are to prevent tachycardia, hypotenison, and possibly hypertension. Volatile inhalation agent help contribute to providing stable hemodynamics. The two most studied inhalation agents utilized in patients with CAD is sevoflurane and isoflurane.

Isoflurane was initially thought to cause coronary steal, but current research has challenged that theory. Coronary steal occurs when blood is redistributed from an area of poorly perfused ischemic myocardium to an adjacent nonischemic area that is already perfused. Certain factors need to be present in order for coronary steal to occur. First systemic blood pressure has to be maintained to ensure adequate coronary perfusion pressure. Secondly a steal-prone anatomy should be present. This has been defined as total occlusion of one coronary artery and 50% or greater stenosis of a second artery that supplies collateral flow to the former vessel (Agnew et al., 2002).

Several human studies have provided evidence in support of isoflurane for the use in patients with CAD. Slogoff et al. (1991) conducted a large study of 1012 patients undergoing coronary artery bypass graft (CABG). The results found no difference in the frequency of myocardial ischemic episodes between patients randomly assigned to receive halothane, enflurane, isoflurane or sufentanil, and no difference between patients with or without coronary steal-prone anatomy. Leung, Hollenberg, O'Kelley, Kavia & Mangano (1992) studied 186 patients undergoing CABG and found no differences between isoflurane and sufentanil groups or those with and without steal-prone anatomy. Both of the studies maintained coronary perfusion pressure by ensuring arterial blood pressure and heart rate were kept within narrow ranges from baseline. Isoflurane has been exonerated from causing coronary steal and has now been shown to decrease myocardial reperfusion injury, limit infarct size and protect the myocardium. Initially, much of the evidence was from animal studies, but human studies are now confirming this effect (Agnew et al., 2002).

Sevoflurane is a volatile anesthetic that is similar to isoflurane in its cardiovascular effects. In adults, heart rate remains relatively stable despite increasing the MAC of the drug. In distinct contrast to desflurane, sevoflurane has not been associated with tachycardia or hypertension during its initial administration by mask or when the inspired concentration is increased during the intraoperative period. Sevoflurane is the least pungent of all the volatile anesthetics and is three times more potent than desflurane (Ebert, 1996).

Current research indicates that sevoflurane increases blood flow to the collateral-dependent myocardium, resulting in no maldistribution of coronary blood flow to perfusion-deprived areas (Kitahata et al., 1999). Sevoflurane attenuates reperfusion injury, resulting in improvement of myocardial metabolic or mechanical recovery in human myocardium (Roscoe, Lynch & Baum, 1999). Sevoflurane is known for its stable hemodynamic profile, steady heart rate, and potential cardiac protection makes it an appealing inhalation agent in patients with coronary artery disease.

Rooke, Ebert, Muzi & Kharasch (1996) conducted a study to examine the effects of sevoflurane in comparison to isoflurane in 214 patients with ischemic heart disease or multiple risk factors scheduled for elective surgery. Patients were randomly assigned to receive sevoflurane or isoflurane for anesthetic maintenance in conjunction with fentanyl and nitrous oxide in oxygen. Creatinine, blood urea nitrogen and urine protein were measured before surgery, immediately after surgery and 24 and 48 hours postoperatively. Results indicated that neither anesthetic was associated with a more frequent treatment for hemodynamic deviation. After surgery, creatinine and bun decreased in both groups. The conclusion was that hemodynamic stability in patients with hypertension and ischemic heart disease is similar with sevoflurane and isoflurane.

Intraoperative monitoring

Perioperative ischemia is common in patients with CAD or at risk for CAD undergoing noncardiac surgery. Ischemic injury can lead to a delay in extubation, hospital discharge, and can overall affect the quality of life. Unfortunately myocardial ischema leads to a disproportionate consumption of heath care resources. Ischemia is defined as a metabolic supply-demand imbalance at the cellular level. As a result of the ischemic injury the body is unable to efficiently remove metabolic wastes, which further contributes to ischemia. Myocardial ischemia is the single most important potentially reversible risk factor for cardiovascular complications (Riedel, Jacobs & El-Etra, 1998).

Electrocardiography (ECG) is the most widely employed monitor of myocardial ischemia because it is inexpensive, easy to use, noninvasive, and readily available (Selbst & Comunale, 2002). Intraoperative recording of the ECG is routinely used in the operating room, post-anesthesia and intensive care units. The most specific sign of myocardial ischemia is depression of the normally isoelectric ST-segment of one or more mm from the baseline. A more definite change is required to define ischemia if the ST-segment is up or downsloping at baseline. An elevation of the ST-segment is usually indicative of an early sign of a lesion that is evolving into myocardial ischemia or infarction. Inversion of the T wave has low specificity and is generally not included as an isolated diagnostic sign of ischemia (Bigatello & Coppo, 2001).

Perioperative ST-segment changes are common in patients undergoing vascular surgery. In several large scale studies of vascular and high-risk noncardiac surgery patients, perioperative ST-segment changes were associated with an increased incidence of perioperative cardiac events, suggesting that these changes are indicative of myocardial ischemia secondary to CAD. These findings have lead to an intense interest in both detection and treatment of perioperative ST-segment changes (Landesberg et al., 1993). On the opposite side of the spectrum are the low- risk patients, in which perioperative ST-segment changes are rarely indicative of coronary artery disease. In a study conducted by Matthew, that looked at healthy women undergoing cesarean sections who frequently have ST-segment depression. The results indicated that the ST-depression was due to secondary coronary artery stenosis (Matthew et al., 1992).

The choice of ECG leads to record is dictated by the patient history. For example, if a patient has a known area of myocardium at risk revealed from preoperative testing, the lead overlooking that area should be monitored (Bigatell & Coppo, 2001). An ECG monitor that can simultaneously display two channels is optimal in detection of ischemia. Lead II is superior for monitoring the cardiac rhythm because of the clarity and size of the P wave. The precordial leads are known to be most sensitive for detecting myocardial ischemia (Skidmore, 2001).

In a study conducted by London, Holledberg & Wong, (1988) a large cohort of patients with known CAD undergoing noncardiac surgery, mainly vascular surgery found that V5 was the most sensitive in detecting 75% of ischemic events. Simultaneously monitoring leads V4 and V5 increased the sensitivity of detecting ischemia to 90%. Where as the standard monitoring of lead II and V5 together only showed 80% sensitivity to detecting ischemia. Many monitors allow the provider to display more than two leads at the same time, but this may transiently take away space for other monitor traces.

A current study conducted by Landesberg, Mosseri, Yehuda, Vesselov & Weissman (2002) looked at perioperative myocardial ischemia using a five electrocardiographic with only one precordial lead placed at the position. One hundred eighty-five consecutive patients undergoing vascular surgery were monitored by continuous 12-lead ST-trend analysis during and for 48072 hours after surgery. The results indicated that the V4 lead was the most sensitive in detecting prolonged postoperative ischemia and infarction. In addition, more than one precordial lead is necessary to approach 95% or greater sensitivity in detecting ischemia and infarction.

Currently in the operating rooms many intraoperative monitors are equipped with computerized analysis of the ST-segment. Different from the earlier versions, which were prone to a high incidence of false positives due to noise interference. The modern computer assisted devices are becoming more accurate in their detection. Although important differences exist among manufactures, many have common features. The common features consist of the monitor learning the basic shape of the QRS complex either by taking an average of numerous beats or as a representative beat, and uses it as a template, which can than be updated and modified. The ST-segment changes are measured in comparison to this highly individualized and dynamic template. They have the capability to efficiently filter noise and artifact and diagnose ischemia based on diagnostic algorithms (Bigatello & Coppo, 2001).

Intraoperative myocardial ischemia

Treatment is initiated when ST segment changes on the electrocardiogram reach 1mm in patients at high risk for developing myocardial ischemia. Immediate pharmacologic treatment of changes in blood pressure and heart rate is necessary. Beta-blockers are often used for a persistent increase in heart rate. Esmolol or labetolol are usually the drugs of choice. Nitroglycerine is a more appropriate choice when myocardial ischemia is associated with a modestly elevated systemic blood pressure. Nitroglycerine decreases preload, which results in increased subendocardial blood flow.

Hypotension is treated with sympathomimetic drugs to restore perfusion through atherosclerotic coronary arteries. Ephedrine increases blood pressure by increasing myocardial contractility and systemic vascular resistance. Phenylephrine is a good choice when the heart rate is high. The dose of phenylephrine that is needed to constrict arteries is less than the dose needed to constrict veins, thus reducing the likelihood of drug-induced coronary artery vasoconstriction by stimulation of the alpha- receptors in the coronary arteries.

Fluids are also essential to increase blood pressure. Fluids are helpful due to the myocardial oxygen requirements for volume work of the heart and are less than those for pressure work. Fluid administration increases preload, which leads to decreased subendocardial perfusion and ischemia. The overall goal is to restore blood pressure, which will maintain pressure dependent flow through the coronary arteries narrowed by atherosclerosis (Stoelting & Diedorf, 2002).

Temperature control

Hypothermia adversely affects essentially every body system. It increases the risk of cardiac morbidity and postoperative infection, and increasing the length of postoperative recovery and hospitalization (Frank et al., 1997). Virtually all anesthetics impair thermoregulation, which in combination with the cold operating rooms, open body cavities, and intravenous fluid and blood administration, result in hypothermia in the majority of surgical patients. Despite routine perioperative thermal care, approximately one half of all patients develop hypothermia to a core temperature less than 36 degrees

Celsius, and approximately one third of patients develop hypothermia to a temperature of less than 35 degrees Celsius during surgery (Frank et al., 1992).

Hypothermia initially stimulates the cardiovascular system, leading to an increase in heart rate, blood pressure, and cardiac output. In addition, it has been recognized that even mild hypothermia (.5 –1.2 degrees below normal core temperature) triggers sympathetically mediated hypertension resulting from a 100-700% increase in circulating levels of norepinephrine which results in a generalized systemic vasoconstriction (Frank et al., 1997). When core temperature decreases by 1.0 degree Celsius shivering occurs and total-body oxygen consumption increases, which leads to an increased demand on the cardiovascular system (Bay, Neinn & Prys-Roberts, 1968). It has been hypothesized that these adrenergic and metabolic responses to hypothermia can upset the balance between myocardial oxygen supply and demand and lead to myocardial ischemia or infarction (Frank et al., 1997).

Frank et al. (1997) conducted a randomized controlled study comparing routine thermal care to supplemental warming care. The subjects consisted of three hundred patients undergoing abdominal, thoracic, or vascular surgery that had CAD or were at high risk for CAD. The results indicated that mean core temperature after surgery was lower in the hypothermic group than in the normothermic group and remained lower during the early postoperative period. Perioperative morbid cardiac events occurred less frequently in the normothermic than the hypothermic group. Hypothermia was an independent predictor of morbid cardiac events by multivariate analysis, indicating a 55% reduction in risk when normothermia was maintained. Postoperative ventricular tachycardia also occurred less frequently in the normothermic group than in the hypothermic group. In conclusion the ability to maintain normothermia is associated with a reduced incidence of morbid cardiac events and ventricular tachycardia.

Elderly patients should be maintained at normal core body temperature. Intraoperative techniques for maintaining core temperature include the use of warmed cotton blankets, a warmed water mattress, warmed IV fluids, heated and humidified inspired gases, and forced air warming. Warmed fluid, humidified inspired gases and forced air warming is the most effective and the safest method to warm patients (Kurz et al., 1993).

Fluid management

Older patients often arrive in the operating room with depleted volume because of overly conservative nothing by mouth orders, reduced thirst, age-related decline in renal capacity to conserve water and salt, disease associated fluid and electrolyte loses, inadequate intravenous fluid substitution and more frequent use of diuretics. The elderly have decreased left ventricular compliance and limited beta-adrenoceptor responsiveness, especially those with hypertension are more sensitive to fluid overload. Careful volume assessment before induction of anesthesia is more important in the elderly than in the young, especially when major fluid shifts are anticipated during surgery (Priebe, 2000).

The primary goal of perioperative fluid management is to maintain or restore tissue perfusion with sufficient amounts of isotonic, sodium-containing solutions, natural and chemically derived colloids, and rarely hypertonic saline (Gowan, 1996). Intraoperative fluid calculations consist of providing fluid for maintenance requirements, deficits caused by hemorrhage and surgical trauma, and insensible loses. Maintenance fluid requirements are calculated based on body weight and patient age. Adults generally require 2ml/kg per hour. Replacement fluids are used to correct body fluid deficits that may occur secondary to gastrointestinal drainage, wound oozing, visceral effusions, or interstitial edema (Nagelhout & Zaglaniczny, 2001). Plasma volume should be maintained with replacement of 4ml/kg/h for minimal surgical trauma, 6ml/kg/h for moderate surgical trauma, and 8ml/kg/h for severe surgical trauma.

The intraoperative management of fluid therapy has great potential to influence intraoperative and postoperative morbidity and mortality. Awareness of preoperative hemodynamic status, particularly as it influences the preload/ventricular output relationship is critical in avoiding serious cardiovascular complications early in the course of anesthetic induction and maintenance. The implications of anesthetic pharmacology, positioning, thermoregulation, ventilatory support, surgical manipulation, operative site, duration, tissue trauma, and blood loss must be appreciated in determining how much fluid to administer. It is essential to provide adequate intravascular volume and preload for adequate vital organ perfusion. The anesthetist has to take into consideration oxygen-caring capacity, coagulation, electrolyte, acid- base balance, and glucose metabolism in choosing the appropriate fluid and amount. Personal preference, cost, and most importantly physiologic evaluation and approaches guide clinical practice (Rosenthal, 1999). The author is not going to get into what type of fluid and the correct amount to administer in this paper. Much controversy exists in the literature in reference to those two concepts.

Excessive fluid loads in the patient with cardiovascular compromise may result in acute cardiac decompensation and pulmonary edema. Frequently, patients with compromised cardiac function additionally are monitored with a central venous pressure or pulmonary artery pressure monitor. The central venous pressure or pulmonary artery pressure allows the clinician to determine how much the heart can handle a fluid load but it does not indicate if fluid load is adequate. Clinical signs of restored perfusion indicate adequate fluid replacement (Nagelhout & Zaglaniczny, 2001).

Patients with a history of congestive heart failure do not have normal heart function and will not tolerate aggressive increases in preload. Excessive fluid therapy may compromise coronary flow due to increased filling pressures. Frequent hemodynamic monitoring and evaluation is necessary to optimize preload (LoBato, 2000).

Postoperative

The postoperative period can be stressful, due to the onset of pain during emergence from anesthesia, fluid shifts, temperature changes, and alteration of respiratory function. Marked changes occur in plasma catecholamine levels, hemodynamics, ventricular function, and coagulation (Mangano, 1990). The postoperative period represents three common cardiovascular complications in the first 48 hours after surgery. The three conditions consist of ischemia, arrhythmia, and pulmonary congestion.

Ischemia is almost always silent and usually not manifested by symptoms of typical or atypical chest pain, hypoperfusion or ventricular failure (Mangano, 1990).

Evidence is indicated by the ECG or elevated cardiac enzymes with an infarction (Blaustein, 1995). A number of factors could account for the silent ischemia. For example patients with ambulatory ischemia, possibly due to defects in pain threshold and perception. Postoperative residual anesthetics, analgesic effects and somatic sensory enervation may further blunt the perception of, reaction to, or communication of painful ischemic symptoms (Mangano, 1990).

The majority of arrhythmias occurring postoperatively are usually self-limited and related to reversible factors such as pain, fluid and electrolyte imbalance, metabolic disturbances, hypoxia or fever. Some other factors could be the effects of proarrhythmic drugs administered during surgery. Drug toxicity could also be a cause of arrthymias and should be evaluated prior to treatment of arrthymias. Patients with a history of significant arrhythmia should resume their medication as soon as possible.

Ventricular ectopic activity is common postoperatively but is not an independent marker of a poor long-term outcome. Antiarrhythmic pharmacotherapy is recommended only to treat or prevent significant hemodynamic or sustained arrhythmias. If atrial flutter or fibrillation occurs it is not necessary to consider anticoagulation. Those rhythms are generally short-lived and revert. For any new arrhythmia that recurs or requires sustained therapy the patient should be reevaluated before discharge to access whether the underlying cardiac status has changed (Blaunstein, 1995).

Bradyarrhythmias that occur in the postoperative period are usually secondary to some other cause, such as certain medications, and electrolyte disturbance, hypoxemia, or ischemia. When they occur on an acute basis, many of the patients will respond to intravenous medications such as atropine, and some will respond to intravenous aminophylline. Bradyarrhythmias due to sinus node dysfunction and advanced conduction abnormalities such as a complete heart block will respond to temporary or permanent pacing (Eagle et al., 2002).

Pulmonary congestion occurs as a result of excess volume administration in patients with normal hearts or left ventricular systolic or diastolic dysfunction, hypertension, or postoperative myocardial infarction. The majority of patients at risk can be identified preoperatively and if necessary monitored closely in the intensive care unit. Sometimes the presentation can be masked if the patient is mechanically ventilated, confused, or has some pre-existing airway disease. Its appearance may be delayed until fluid sequestered outside the circulation is mobilized, or occasionally may accompany renal failure. Normally pulmonary congestion is easily managed with diuretic therapy and close regulation of fluid administration and blood replacement with close observation of renal function. When pulmonary edema occurs unexpectedly a silent myocardial infarction should be suspected and evaluated with ECGs and serial cardiac enzymes (Blaunstein, 1995).

Cardiologists believe that pain management is a crucial aspect of perioperative care. The postoperative period is the time when stress ablation, adverse hemodynamics, and hypercoagulable responses are crucial to prevent adverse events. Pain stimulates activation of the nervous system and other reflexes that serve as a major release of the endocrine metabolic response, which contributes to various organ dysfunction (Kehlet & Holte, 2001).

Postoperative pain increases the risk of adverse outcomes in elderly patients by contributing to cardiac events such as: ischemia, hypertension, tachycardia and hypoxemia. Effective use of analgesia can help reduce the incidence of myocardial ischemia and pulmonary complications accelerate recovery, promote early mobilization, shorter hospital stays and decreased medical costs. Early mobilization after surgery can prevent deep venous thrombosis and decreases morbidity and mortality in patients. These benefits can be achieved by epidural anesthesia or balanced analgesia. Many times postoperative pain control is inadequate in the elderly due to concerns about drug overdose, adverse responses or a risk of opoid addiction. Sometimes it is difficult to assess postoperative pain in the elderly due to mental status changes (Jin & Chung, 2001).

According to Kehlet and Holte, there is a pronounced differential effect of the various postoperative pain-relieving techniques on surgical stress responses. Regional techniques, and preferably continuous techniques with local anesthetics, may lead to a reduction in the surgical stress response. Epidural opiod techniques are the least effective on ablating the stress response of surgery and are comparable with systemic opiod techniques and the use of NSAIDs. The popular technique of high dose opiod anesthesia suppresses intraoperative but not postoperative stress response (2001).

Recommendations

Nursing Research

The percentage of patients with CAD having adverse cardiac events has declined due to advanced technology and improved anesthetic technique. This author feels that current studies conducted to look at the number of patients having adverse cardiac outcomes may be beneficial. Research studies have not shown a difference in regional versus general technique in preventing adverse cardiac outcomes. It may be interesting to repeat those studies currently today and see if any difference would be noted.

Continued research should be conducted on the use of noninvasive tests to determine what is appropriate for different patient populations. Studies looking at percutaneous transluminal coronary angioplasty and coronary artery bypass graft surgery in reference to beneficial effects and cost savings for prevention of cardiac events should be continued. Research should be conducted to establish optimal guidelines for selected patient subgroups, particularly the elderly and women. As far as monitoring goes they could look at the efficacy of monitoring patients for myocardial infarction and ischemia, particularly the role of monitoring in affecting treatment decisions and outcomes. This author feels that studies that look at the overall cost-effectiveness of various methods of noninvasive testing to reduce cardiac complications could be beneficial.

Several studies have documented that the incidence of perioperative myocardial ischemia is greatest in the postoperative period. More attention needs to be directed to postoperative care and preventing adverse cardiac outcomes. More research aimed at preventing the surgery-induced neurohumoral changes during the postoperative period would be helpful in decreasing myocardial ischemia and infarction.

Nursing Practice

The use of beta-blockers and clonidine in the operating room has become popular for the prevention of adverse cardiac outcomes in patients with a history of CAD.

Continued studies need to be conducted to validate the current studies. The use of clonidine and beta-blockers given preoperatively should be utilized in practice to determine the overall effect on the incidence of cardiac events. Nurse anesthetists need to stay current in techniques that help minimize the risk of adverse cardiac outcomes by attending current seminars and educational meetings. The population continues to grow older and anesthesia providers will come into contact with patients who have a history of CAD on a daily basis. Prompt recognition of ischemia is pertinent in preventing a myocardial infarction and providers need to be vigilant and recognize ischemia immediately and prompt treatment is essential.

Nursing Education

Training and educating anesthesia providers in current techniques that minimize the risk of adverse cardiac outcomes are pertinent. It is important to stay current in new drugs and their mechanism of action and adverse effects in order to choose the most appropriate drug based on the patients history. Critical thinking skills are needed to respond to situations in the operating room and educational programs should offer seminars to develop those skills. It is also imperative that student nurse anesthetists care for a large number of patient's with CAD to help develop their skills and techniques.

Nursing Policy

Current technology has improved the capabilities of the anesthesia provider in recognizing myocardial ischemia through ST segment monitoring. The prompt recognition of ischemia helps facilitate interventions to prevent a myocardial infarction. This author feels that all operating rooms should be equipped with the newest and current

ST segment monitors to help identify ischemia. A policy should be established that every anesthesia provider monitor ST segments continuously through out the operation.

Conclusion

The content of this paper has looked at the anesthesia considerations in patients with coronary artery disease going for noncardiac surgery. The paper was written as guide to help nurse anesthetists in practice choose their anesthesia plan based on what is beneficial for that particular group of patients. New technology and anesthetic techniques have helped reduce the incidence of adverse cardiac events in high-risk patients. As the current population continues to age anesthesia providers will come into contact on a regular basis with patients with CAD. The goal of anesthesia is to provide safe and efficient care with the least amount of adverse events possible.

This author has addressed the current recommendations for preoperative testing for patients with CAD. The anesthesia considerations, relating to preinduction, induction, and maintenance phase were addressed in regards to CAD. Finally treatment options for myocardial ischemia and infarction were addressed during the intraoperative phase. The postoperative phase covering the most common arrhythmias and pain control was addressed in this paper.

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